

SR 520 Westbound Ramp Meter Effects

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BACKGROUND

On August 14, 2000 the ramp meter from 84th Ave NE to westbound SR 520 was activated during the afternoon commute. About a month later on September 19, 2000 a number of other SR 520 ramp meters were activated including 104th NB to WB, 104th SB to WB, 108th to WB, and 124th to WB. Due to construction on SR 520, there was a lack of continuous, operational data stations east of I-405 prior to the beginning of the ramp metering operation. For that reason we limited our study area to the three-mile stretch between the Floating Bridge and I-405. We took data from approximately six months after the ramp metering operation began and compared that with data from one year earlier to eliminate seasonal variation. We used three weeks of Tuesday, Wednesday, Thursday data from both before and after ramp metering in order to come up with average weekday numbers. The before and after dates were 1-25-00 to 2-10-00 and 1-30-01 to 2-15-01, respectively. We calculated averages for mainline volumes and speeds, on-ramp volumes, and one off-ramp volume which proved significant in the course of our analysis. We calculated half hourly averages from 5:00 to 10:30 in the morning and from 2:00 to 7:30 in the afternoon. A number of before and after congestion graphs were generated and the on and off times of the ramp meters were extracted from the VAX operator log.

In addition to data collected from our embedded loop detectors, we performed a queue study on 84th Ave and NE 28th St leading to the westbound on-ramp. These two arterials were singled out in order to study bypass behavior. The lengths of the queues were recorded every five minutes during the PM peak periods before and after ramp metering. All data tables are available in the Appendix. Graphs have been generated for some of the more interesting data and are included in the text where appropriate.

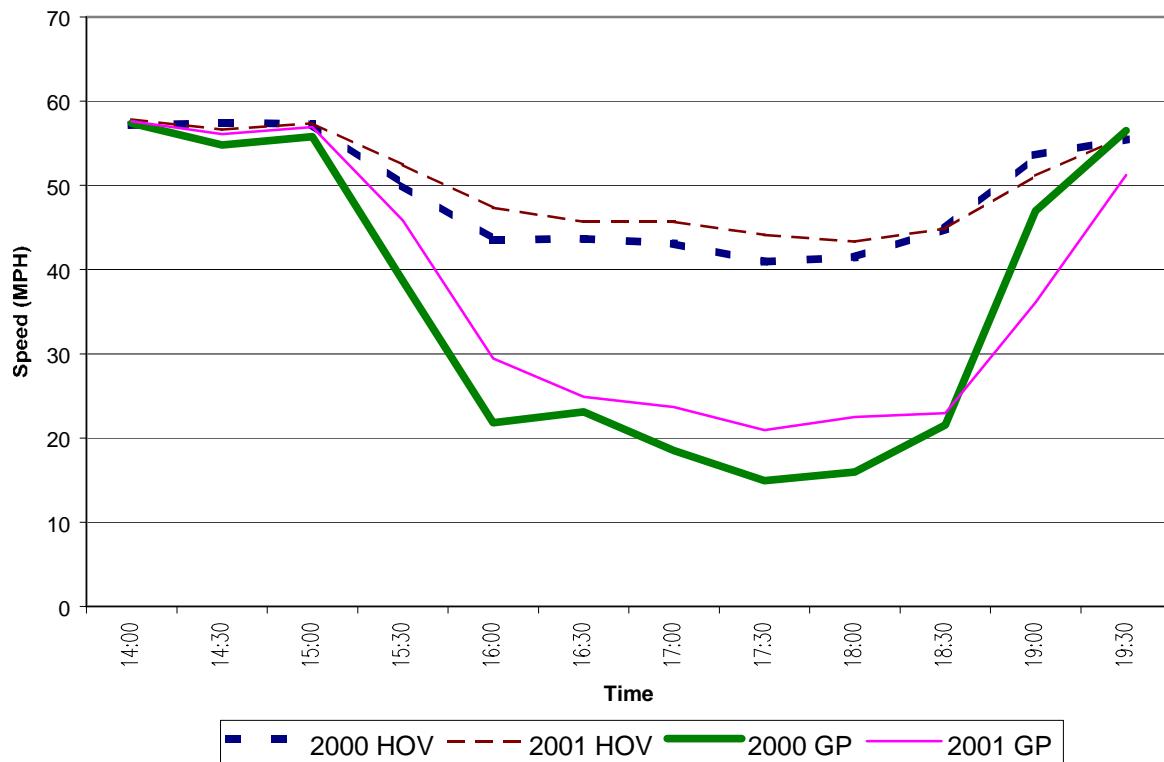
This report concludes the 6 months post-metering study and documents the effects of ramp metering on the SR 520 corridor and the selected adjacent arterials.

PM RESULTS

Speeds

In comparing the speed data we see significant increases in the general purpose lanes between 3:30 pm and 6:00 pm at three of the four stations. The HOV lane speeds followed the same pattern, although the percentage increase was much less dramatic than in the GP lanes (see Figure 1 below). Both the HOV and GP lanes followed a general trend in which the speed increases were greatest at the stations farthest west. The farthest east station for which we have speed data (104th Ave) showed the least favorable results. The HOV lane showed speed decreases throughout the PM peak while the GP lanes showed large increases at some times and large decreases at others.

Figure 1. PM Speeds, Westbound SR 520 at 92nd Ave NE



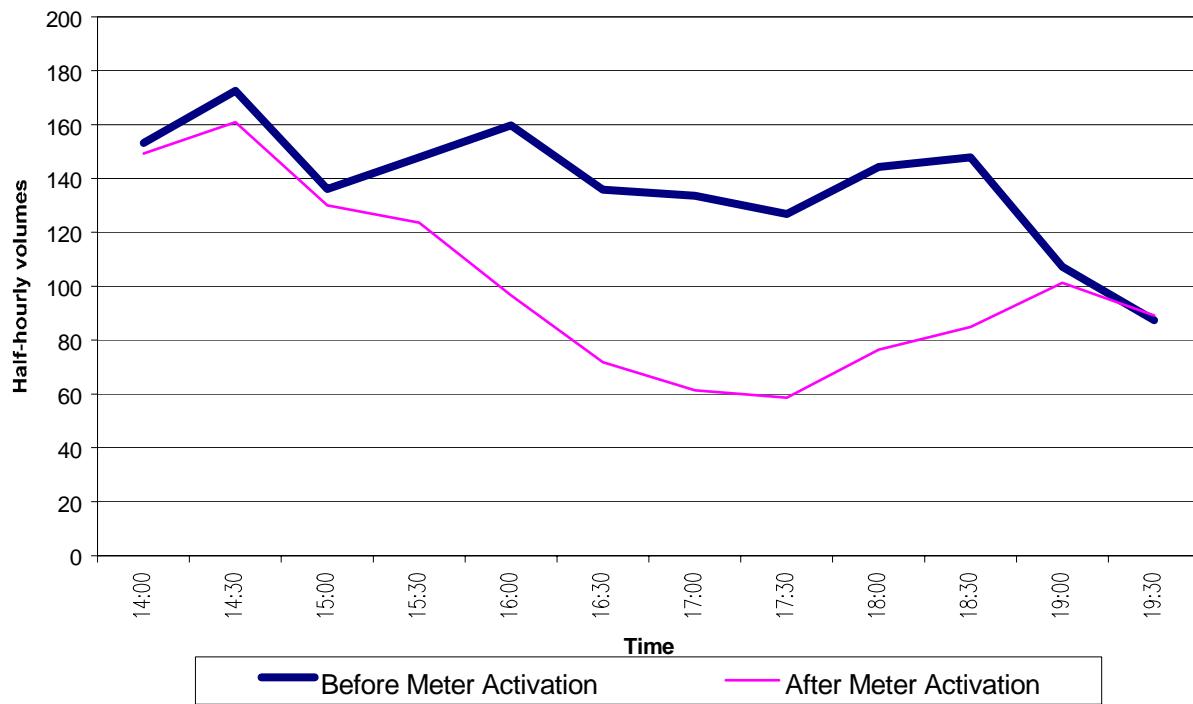
A couple of trends were particularly interesting in the GP lanes. At 4:30 pm the speeds of the three westmost stations increased slightly but significantly less than during the surrounding time periods. The eastmost station at 104th even shows a speed decrease during this time. Another interesting trend was a significant decrease in speeds occurring towards the end of the evening commute. This seems to be more of a function of when traffic growth occurs rather than the operation of the ramp meters. Since the peak periods are already so congested, traffic growth

occurs during the fringes of the peak period where capacity has not yet been reached. We should extend our times of operation to match the growth of the peak period.

Mainline Volumes

Almost every measurement of PM volumes showed increases. The notable exception was the HOV volume at 98th Ave NE, which showed decreases for most of the PM peak period. Our theory is that because of the increased speeds on the mainline fewer people exited at 92nd Ave NE to use the 84th on-ramp as a bypass of mainline congestion. We collected data for the 92nd Ave NE off-ramp (shown below in Figure 2) and found decreases in volume of 40 to 55% between 4:00 and 6:30 pm. Less people were getting into the HOV lane to use the 92nd exit and the HOV detector just upstream reflected that.

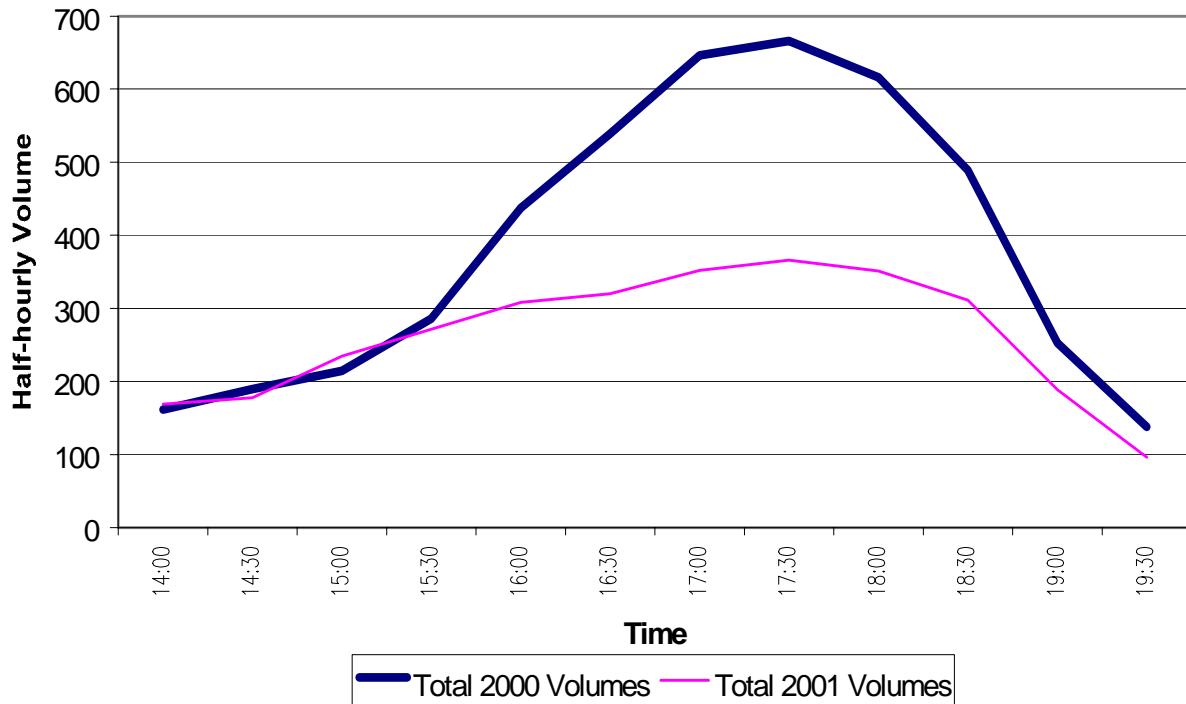
Figure 2. 92nd Ave NE PM Off-ramp Volumes



Ramp Volumes

The most significant change in ramp volumes was the dramatic decrease at 84th Ave NE (see Figure 3 on the next page). Between 4:00 and 6:30 pm we see decreases between 40 and 56%. As mentioned above this was partly due to the decrease in cut through traffic coming from the 92nd off-ramp. Another portion shows itself in the increase in volume on the northbound 104th ramp. Together these two only account for about half the volume reduction at 84th Ave NE. Unfortunately there is no before data for the 108th Ave NE ramp so we can't tell if there was a corresponding increase at that ramp or others farther east.

Figure 3. 84th Ave NE On-ramp to WB SR 520 Volumes



Also one should note that the 104th Ave NE NB ramp was restriped just prior to the start of metering operations. It had previously been striped as just one lane, although the loop detectors for the future GP and HOV bypass lanes were already in place. It doesn't appear that there was double-counting of vehicles between the GP and HOV lanes, but the 2000 HOV volume was too high as we see a decrease in HOV volume after ramp metering began. We believe the total volumes (GP + HOV) to be accurate and used those in our comparisons.

Congestion

A common measure of the severity of traffic congestion is loop occupancy, the percentage of time that a loop detector is activated, or occupied, by vehicles traveling over it. We used occupancy data to generate congestion graphs that illustrate the average congestion during our study dates (see Figures 4 and 5 on the next page). These graphs show that the severity of PM congestion has been reduced and its onset has been delayed following ramp meter activation.

The average time at which highway conditions deteriorate from "wide open" to "moderate" now occurs about 20 minutes later than a year ago. Even though "stop and go" conditions still exist during large portions of the evening peak period, the duration of these conditions is much shorter now than prior to the metering operation. Another trend illustrated by the congestion graphs is the traffic growth near the end of the peak period, as described in the Speeds section. "Heavy" congestion conditions now end about 10 minutes later than they did last year.

Figure 4. Average PM Weekday Occupancy Westbound SR 520, 1/25/00 - 2/10/00

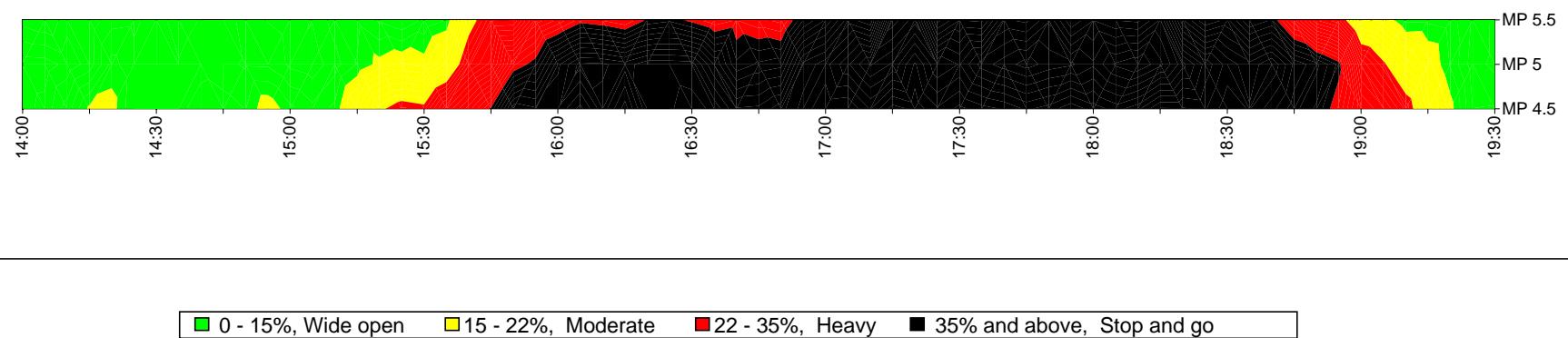
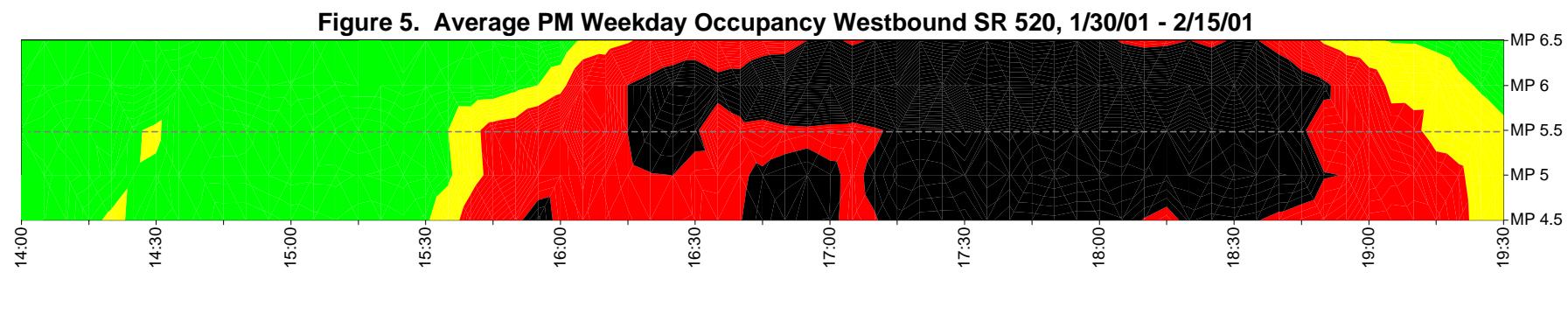


Figure 5. Average PM Weekday Occupancy Westbound SR 520, 1/30/01 - 2/15/01



84th Queue Study

In an effort to monitor the impacts of ramp metering on the unusually long queues on 84th Ave NE and NE 28th St / Points Dr NE leading to the 84th Ave on-ramp, we collected PM queue length data both before and after meter activation. In light of the 50%+ decreases in ramp volume at 84th, it is hardly surprising that queue length declined dramatically. The queue on NE 28th St / Points Dr NE—the approach used for the 92nd exit cut-through—underwent the larger decrease (see Figure 6). During the period of highest ramp volume, the queue length decreased over 700 m. For most of the PM peak, the queue on this approach no longer extends beyond the four-way stop at 84th Ave NE and NE 28th St. The queue on 84th also decreased significantly, shortening by over 400 m during the period of greatest volume (see Figure 7). These queue length reductions bolster the theory that much of the cut through traffic to the 84th on-ramp is entering the freeway at other ramps and no longer using the 92nd exit as a congested freeway bypass.

Figure 6. NE 28th St / Points Dr NE PM Queue Lengths

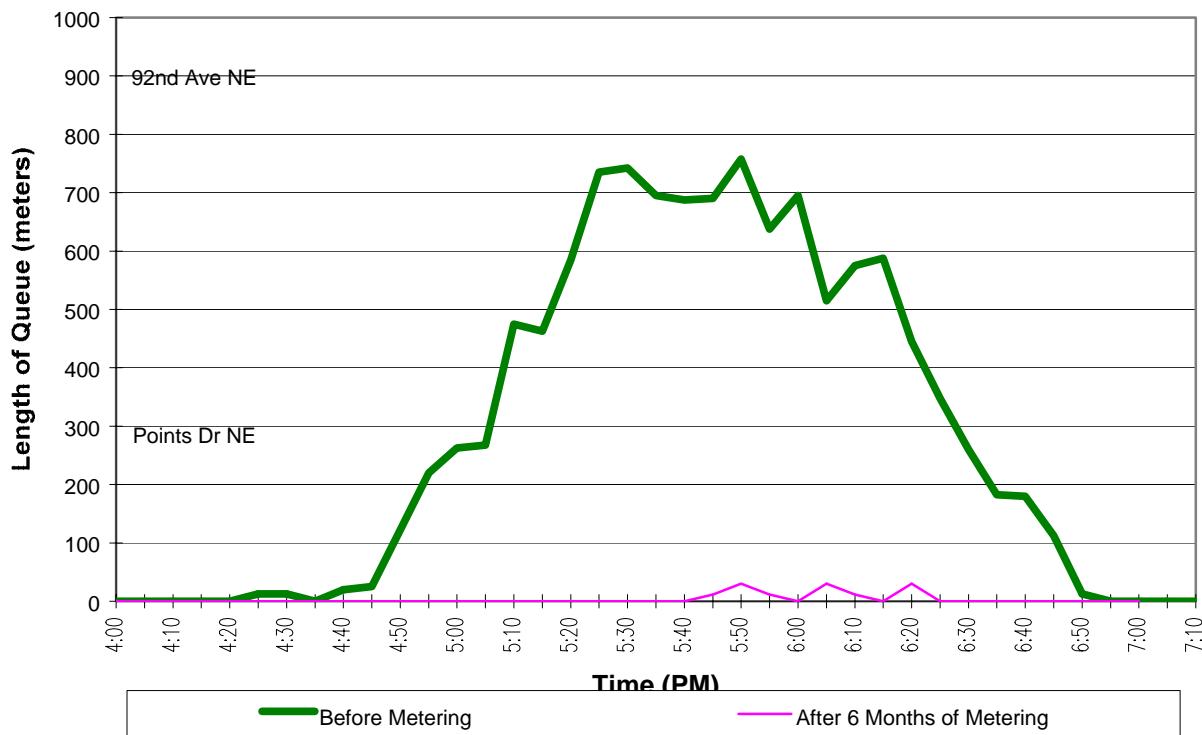
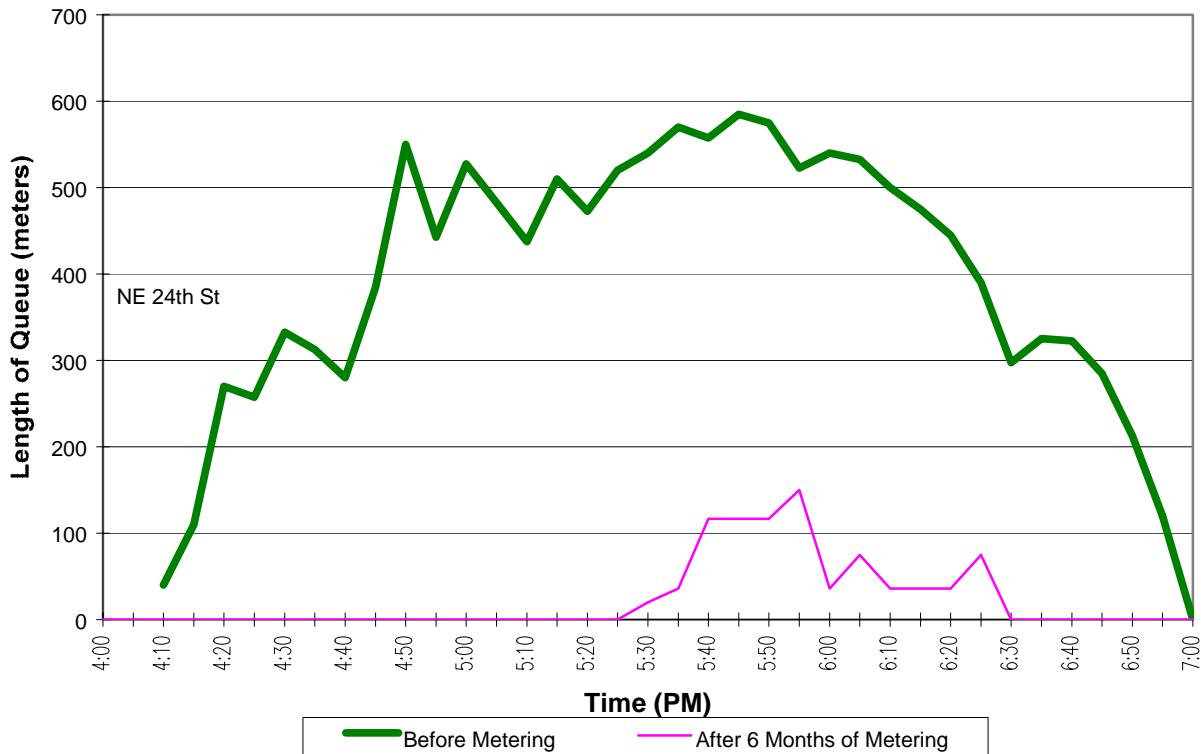


Figure 7. 84th Ave NE PM Queue Lengths



AM RESULTS

Speeds

The activation of ramp meters seems to have had no significant effect on morning peak speeds. HOV speeds showed small fluctuations up and down with no substantial changes. Generally the GP lanes were similar with some exceptions. In particular the stations at 84th and 92nd showed significant decreases at 7:30 and 8:00 am. Although this interval's speeds are the lowest of the AM peak, they are still 25 – 30% higher than the lowest speeds of the evening commute. Other exceptions included the surprising speed increases at 104th of about 25% at 7:00 and 8:30 am.

Mainline Volumes

AM volumes changed much less significantly than those for the PM peak period. Although there was some fluctuation and occasional periods of volume decreases, both GP and HOV lanes tended to display slightly increased volumes. The GP lanes at 84th Ave NE were a notable exception, showing minor volume decreases for nearly all of the morning peak period.

Ramp Volumes

As explained in PM Results the restriping of the 104th Ave NB ramp especially affected the HOV counts. Again we feel that the total volume for that ramp is reasonably accurate. On the other ramps for which counts are available, the HOV volume rose markedly. This increase is to be expected following a ramp meter turn-on. Surprisingly, however, the total ramp volumes show overall decreases throughout the AM peak hours. As mentioned above, mainline volumes during the same period generally rose slightly. This suggests that more motorists are now entering the freeway from on-ramps east of 104th Ave NE.

Congestion

Like speeds and mainline volumes, AM congestion changed little (see Figures 8 and 9 on the next page). The initial onset of congestion was delayed by approximately 25 minutes. However there was also a five-minute delay in the average time at which congestion clears up. The congestion severity was basically unchanged.

Figure 8. Average AM Weekday Occupancy Westbound SR 520, 1/25/00 - 2/10/00

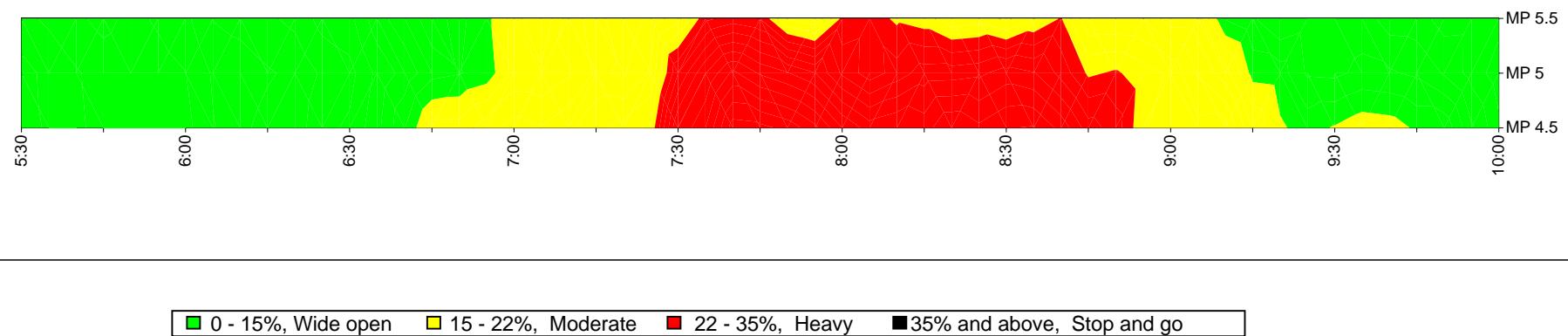


Figure 9. Average AM Weekday Occupancy Westbound SR 520, 1/30/01 - 2/15/01

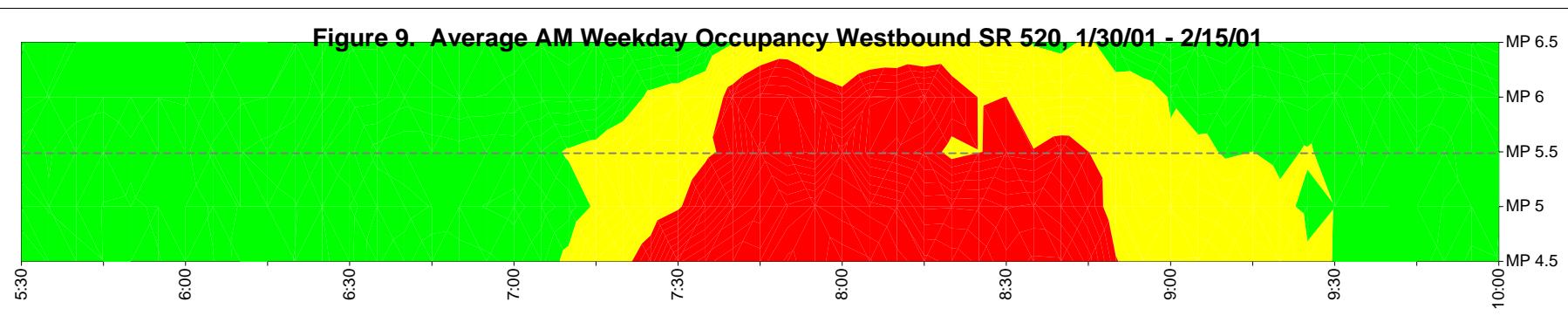


Table A1. AM Mainline Speeds, Westbound SR 520

	84th Ave NE				92nd Ave NE				98th Ave NE				104th Ave NE			
					HOV Lane											
Time	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change
5:00	59.6	61.7	2.0	3.4%	52.0	58.8	6.9	13.2%	51.0	54.5	3.5	6.9%	56.6	44.6	-12.0	-21.2%
5:30	60.9	60.7	-0.2	-0.3%	55.0	53.6	-1.4	-2.6%	54.7	55.3	0.6	1.1%	57.1	49.6	-7.5	-13.2%
6:00	58.0	57.3	-0.7	-1.2%	50.4	49.7	-0.7	-1.3%	54.2	53.3	-0.9	-1.6%	55.3	49.0	-6.3	-11.4%
6:30	55.2	58.3	3.1	5.6%	50.6	51.6	0.9	1.9%	52.5	54.4	2.0	3.8%	53.8	50.0	-3.8	-7.1%
7:00	52.1	54.2	2.1	4.0%	49.9	52.0	2.1	4.2%	49.9	52.8	2.8	5.7%	53.4	50.5	-2.9	-5.4%
7:30	46.1	44.6	-1.5	-3.3%	49.2	47.8	-1.4	-2.8%	49.7	47.8	-1.9	-3.8%	51.1	46.9	-4.2	-8.2%
8:00	48.5	46.6	-1.9	-4.0%	50.3	49.2	-1.1	-2.3%	49.8	49.3	-0.5	-1.0%	50.9	48.0	-3.0	-5.8%
8:30	50.5	51.3	0.8	1.6%	52.5	51.8	-0.7	-1.2%	50.3	51.6	1.3	2.6%	50.9	49.2	-1.7	-3.4%
9:00	55.8	57.8	2.0	3.6%	54.2	56.1	1.9	3.5%	53.3	55.0	1.7	3.2%	54.8	50.1	-4.7	-8.6%
9:30	58.7	59.5	0.8	1.4%	56.6	56.3	-0.2	-0.4%	55.7	55.5	-0.2	-0.3%	56.7	50.5	-6.1	-10.8%
10:00	62.4	62.6	0.2	0.2%	56.9	58.6	1.7	3.0%	56.8	57.2	0.4	0.7%	56.7	52.2	-4.5	-7.9%
10:30	62.6	63.3	0.7	1.1%	56.0	58.5	2.5	4.5%	56.9	57.9	1.0	1.8%	56.8	51.1	-5.7	-10.0%
	General Purpose Lanes															
Time	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change
5:00	64.4	63.9	-0.4	-0.7%	61.1	61.2	0.1	0.2%	58.9	59.1	0.2	0.3%	61.7	64.8	3.1	5.0%
5:30	63.7	64.2	0.4	0.6%	60.4	60.6	0.2	0.4%	57.9	58.9	1.0	1.6%	61.3	64.6	3.3	5.4%
6:00	61.7	62.3	0.6	1.0%	58.2	58.9	0.7	1.3%	55.3	56.5	1.2	2.2%	59.8	63.0	3.2	5.4%
6:30	53.4	57.0	3.6	6.8%	51.6	54.8	3.1	6.0%	47.3	51.8	4.5	9.5%	55.1	61.1	6.0	10.9%
7:00	44.5	47.4	2.9	6.5%	44.7	51.2	6.5	14.5%	42.5	46.9	4.4	10.3%	47.6	59.3	11.8	24.8%
7:30	26.1	20.9	-5.2	-19.9%	37.8	33.5	-4.3	-11.4%	37.6	34.5	-3.1	-8.3%	43.3	43.1	-0.1	-0.3%
8:00	33.6	23.6	-10.0	-29.7%	40.2	31.8	-8.4	-20.8%	37.4	36.4	-1.0	-2.7%	39.3	42.0	2.6	6.7%
8:30	34.9	34.1	-0.8	-2.3%	41.7	40.9	-0.8	-1.8%	39.5	41.2	1.7	4.3%	39.8	49.9	10.1	25.3%
9:00	47.5	48.6	1.1	2.2%	48.6	52.0	3.4	6.9%	48.7	50.7	2.0	4.1%	54.4	56.9	2.5	4.6%
9:30	53.5	56.7	3.1	5.8%	55.1	54.2	-0.9	-1.7%	54.0	52.4	-1.6	-3.0%	59.6	58.0	-1.6	-2.7%
10:00	61.9	59.5	-2.3	-3.8%	58.4	57.5	-0.9	-1.5%	55.9	55.5	-0.4	-0.7%	60.7	62.8	2.1	3.4%
10:30	62.3	62.6	0.2	0.4%	57.8	58.9	1.1	1.8%	55.9	56.8	0.9	1.6%	60.8	63.7	3.0	4.9%

Table A2. PM Mainline Speeds, Westbound SR 520

	84th Ave NE				92nd Ave NE				98th Ave NE				104th Ave NE			
					HOV Lane											
Time	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change
14:00	60.4	62.5	2.0	3.4%	57.2	57.8	0.7	1.2%	56.9	57.7	0.8	1.4%	57.3	51.9	-5.4	-9.5%
14:30	61.3	61.0	-0.4	-0.6%	57.4	56.6	-0.8	-1.4%	56.6	55.2	-1.4	-2.4%	58.0	50.8	-7.2	-12.4%
15:00	57.5	59.8	2.3	4.0%	57.3	57.4	0.1	0.1%	56.2	56.6	0.4	0.7%	57.9	51.0	-6.9	-11.9%
15:30	46.6	49.9	3.3	7.1%	50.1	52.5	2.4	4.8%	49.1	52.3	3.1	6.3%	53.1	50.3	-2.8	-5.3%
16:00	36.6	43.8	7.1	19.5%	43.5	47.3	3.8	8.8%	42.2	46.2	3.9	9.3%	45.0	43.2	-1.8	-4.1%
16:30	36.0	41.8	5.8	16.1%	43.7	45.7	2.0	4.6%	40.9	43.3	2.5	6.0%	44.1	38.6	-5.5	-12.5%
17:00	32.9	42.1	9.2	28.0%	43.1	45.7	2.6	6.0%	39.6	44.1	4.5	11.4%	38.7	35.6	-3.0	-7.8%
17:30	33.6	41.4	7.8	23.3%	40.9	44.1	3.2	7.7%	39.0	43.2	4.3	10.9%	36.0	33.6	-2.4	-6.7%
18:00	35.2	41.5	6.3	18.0%	41.4	43.3	1.9	4.6%	39.9	42.1	2.2	5.6%	41.0	34.8	-6.3	-15.3%
18:30	40.9	43.3	2.4	5.8%	44.8	44.9	0.1	0.1%	44.2	43.3	-0.9	-2.1%	49.0	39.5	-9.5	-19.4%
19:00	54.7	51.0	-3.7	-6.8%	53.6	51.1	-2.4	-4.5%	52.8	48.8	-4.0	-7.5%	53.0	49.0	-4.0	-7.5%
19:30	63.9	59.0	-5.0	-7.7%	55.5	56.0	0.5	0.9%	55.0	54.8	-0.3	-0.5%	56.2	52.9	-3.3	-5.9%
General Purpose Lanes																
Time	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change	2000	2001	Change %	Change % Change
14:00	58.7	60.3	1.6	2.6%	57.4	57.6	0.2	0.4%	54.6	55.8	1.2	2.2%	60.8	63.7	3.0	4.9%
14:30	56.3	56.8	0.4	0.7%	54.8	56.1	1.3	2.4%	52.8	53.0	0.2	0.3%	60.9	61.7	0.9	1.4%
15:00	50.2	57.9	7.8	15.4%	55.8	56.9	1.1	2.1%	53.1	53.3	0.2	0.4%	60.5	62.9	2.4	4.0%
15:30	27.4	33.5	6.1	22.1%	38.6	45.8	7.2	18.7%	38.2	42.9	4.7	12.4%	48.8	58.9	10.1	20.7%
16:00	15.0	20.1	5.1	34.2%	21.8	29.5	7.6	35.1%	24.6	29.3	4.6	18.7%	26.4	33.3	6.9	26.1%
16:30	14.7	18.2	3.5	24.2%	23.1	24.9	1.8	7.7%	21.7	24.2	2.5	11.5%	22.6	20.7	-2.0	-8.8%
17:00	13.7	18.2	4.4	32.3%	18.5	23.7	5.2	27.9%	18.5	22.4	3.9	20.8%	15.4	15.5	0.2	1.0%
17:30	12.9	17.0	4.1	31.5%	14.9	20.9	6.0	40.2%	15.5	20.9	5.4	34.6%	11.3	16.2	4.9	43.3%
18:00	13.1	16.9	3.8	28.8%	16.0	22.5	6.5	40.9%	18.2	23.0	4.9	26.9%	24.7	17.0	-7.7	-31.1%
18:30	16.0	19.7	3.7	23.0%	21.6	23.0	1.4	6.5%	26.1	24.3	-1.8	-6.8%	39.8	23.1	-16.7	-41.9%
19:00	41.8	31.2	-10.6	-25.4%	47.0	36.1	-10.8	-23.1%	46.0	37.1	-8.9	-19.4%	48.0	47.2	-0.8	-1.6%
19:30	60.6	51.8	-8.8	-14.6%	56.5	51.2	-5.3	-9.3%	52.8	50.6	-2.2	-4.2%	55.9	60.9	5.0	8.9%

Table A3. AM Mainline Volumes, Westbound SR 520

	76th Ave NE			84th Ave NE			92nd Ave NE			98th Ave NE			SB 104th Ave NE			NB 104th Ave NE			
	Time	2000	2001	Change % Change															
5:00	No HOV lane	3	4	0 6.5%	4	4	0 8.3%	11	10	-1 -10.3%	10	7	-3 -34.1%	9	13	3 36.1%			
5:30		11	10	-1 -11.8%	11	10	-1 -6.0%	29	33	4 14.7%	25	29	5 19.0%	24	30	6 25.7%			
6:00		25	21	-4 -16.2%	31	24	-7 -22.1%	66	65	-1 -1.8%	52	47	-5 -10.4%	45	47	2 4.2%			
6:30		40	36	-4 -10.2%	42	42	0 1.1%	114	124	10 8.8%	79	79	1 0.8%	77	73	-4 -4.8%			
7:00		88	80	-8 -9.9%	92	86	-7 -7.2%	209	205	-4 -1.9%	134	132	-2 -1.7%	128	122	-6 -4.5%			
7:30		113	122	9 8.2%	106	122	15 14.3%	227	246	19 8.5%	160	197	37 23.0%	151	183	32 21.2%			
8:00		107	122	15 14.0%	100	121	21 21.3%	294	301	7 2.3%	222	229	7 3.0%	204	217	13 6.5%			
8:30		75	78	3 4.6%	70	78	8 11.6%	182	194	11 6.1%	136	137	1 0.6%	115	128	13 11.5%			
9:00		52	58	6 11.6%	48	56	8 17.4%	173	173	0 -0.1%	109	122	13 12.1%	92	109	17 18.2%			
9:30		43	47	5 10.9%	42	53	10 24.6%	159	167	9 5.5%	102	122	20 19.7%	85	108	23 27.5%			
10:00		31	40	10 31.0%	32	41	9 28.8%	142	151	9 6.0%	102	109	7 6.4%	77	86	8 10.9%			
10:30		27	32	4 15.9%	29	37	8 26.5%	146	149	3 2.1%	105	119	15 13.9%	74	89	15 20.3%			
	General Purpose Lanes																		
Time	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	
5:00	311	303	-8 -2.5%	317	293	-24 -7.7%	360	303	-56 -15.7%	406	342	-63 -15.6%	300	291	-9 -3.0%	210	298	87 41.5%	
5:30	701	700	-1 -0.1%	707	666	-40 -5.7%	710	677	-33 -4.6%	737	717	-21 -2.8%	636	653	17 2.7%	566	664	98 17.2%	
6:00	1143	1100	-43 -3.8%	1152	1050	-102 -8.9%	1063	1073	10 1.0%	1105	1089	-16 -1.4%	1027	1006	-21 -2.0%	976	1024	48 5.0%	
6:30	1666	1702	36 2.1%	1648	1600	-49 -3.0%	1511	1619	108 7.1%	1440	1581	141 9.8%	1441	1478	37 2.6%	1479	1482	2 0.2%	
7:00	1807	1895	87 4.8%	1691	1726	36 2.1%	1550	1721	171 11.0%	1526	1711	185 12.1%	1427	1597	170 11.9%	1486	1588	102 6.8%	
7:30	1887	1918	31 1.6%	1624	1592	-32 -2.0%	1537	1658	121 7.9%	1506	1658	151 10.0%	1299	1439	139 10.7%	1381	1433	52 3.8%	
8:00	1876	1897	21 1.1%	1574	1524	-50 -3.2%	1473	1589	115 7.8%	1443	1536	94 6.5%	1243	1315	72 5.8%	1347	1323	-24 -1.8%	
8:30	1815	1831	16 0.9%	1579	1544	-35 -2.2%	1481	1571	90 6.1%	1420	1506	86 6.0%	1269	1319	49 3.9%	1340	1324	-17 -1.2%	
9:00	1672	1695	23 1.4%	1528	1479	-49 -3.2%	1407	1478	71 5.0%	1369	1484	114 8.4%	1283	1347	64 5.0%	1252	1351	99 7.9%	
9:30	1657	1682	25 1.5%	1548	1497	-51 -3.3%	1414	1516	101 7.2%	1421	1517	97 6.8%	1367	1399	32 2.3%	1284	1394	110 8.5%	
10:00	1504	1593	90 6.0%	1427	1432	5 0.3%	1327	1414	87 6.6%	1340	1446	105 7.9%	1263	1327	64 5.1%	1173	1331	158 13.5%	
10:30	1515	1563	47 3.1%	1457	1413	-44 -3.0%	1341	1398	58 4.3%	1379	1439	59 4.3%	1284	1324	40 3.1%	1175	1325	149 12.7%	
	Total (GP + HOV)																		
Time	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	2000	2001	Change % Change	
5:00	311	303	-8 -2.5%	321	296	-24 -7.6%	364	308	-56 -15.4%	417	352	-64 -15.5%	310	297	-13 -4.1%	220	310	91 41.3%	
5:30	701	700	-1 -0.1%	718	676	-42 -5.8%	721	688	-34 -4.7%	766	750	-16 -2.1%	660	682	22 3.3%	590	694	104 17.6%	
6:00	1143	1100	-43 -3.8%	1177	1071	-106 -9.0%	1094	1097	4 0.3%	1171	1154	-17 -1.4%	1080	1053	-26 -2.4%	1020	1071	50 4.9%	
6:30	1666	1702	36 2.1%	1689	1636	-53 -3.1%	1553	1661	108 7.0%	1554	1705	151 9.7%	1519	1557	38 2.5%	1556	1555	-1 -0.1%	
7:00	1807	1895	87 4.8%	1778	1806	28 1.6%	1642	1807	164 10.0%	1735	1916	181 10.5%	1562	1729	168 10.7%	1614	1709	96 5.9%	
7:30	1887	1918	31 1.6%	1737	1714	-23 -1.3%	1644	1780	136 8.3%	1734	1904	171 9.8%	1459	1636	176 12.1%	1532	1616	84 5.5%	
8:00	1876	1897	21 1.1%	1681	1646	-35 -2.1%	1573	1710	137 8.7%	1737	1837	101 5.8%	1465	1543	78 5.3%	1550	1540	-11 -0.7%	
8:30	1815	1831	16 0.9%	1654	1623	-32 -1.9%	1551	1649	98 6.3%	1603	1699	97 6.0%	1406	1456	50 3.6%	1456	1452	-3 -0.2%	
9:00	1672	1695	23 1.4%	1579	1537	-43 -2.7%	1455	1534	79 5.4%	1543	1657	114 7.4%	1391	1469	78 5.6%	1344	1459	115 8.6%	
9:30	1657	1682	25 1.5%	1591	1544	-47 -2.9%	1457	1569	112 7.7%	1579	1685	106 6.7%	1469	1521	52 3.5%	1369	1502	133 9.7%	
10:00	1504	1593	90 6.0%	1458	1472	14 1.0%	1359	1455	96 7.1%	1483	1597	114 7.7%	1365	1436	71 5.2%	1250	1417	167 13.3%	
10:30	1515	1563	47 3.1%	1484	1444	-40 -2.7%	1370	1435	65 4.8%	1525	1588	62 4.1%	1389	1443	55 3.9%	1249	1413	164 13.2%	

Table A4. PM Mainline Volumes, Westbound SR 520

	76th Ave NE			84th Ave NE			92nd Ave NE			98th Ave NE			SB 104th Ave NE			NB 104th Ave NE			
	Time	2000	2001	Change % Change															
14:00	No HOV lane	43	42	-1 -1.8%	43	44	2 3.6%	185	185	0 0.2%	144	161	18 12.3%	90	97	7 7.4%			
14:30		59	59	-1 -1.1%	57	62	5 8.8%	215	211	-5 -2.1%	167	183	15 9.2%	109	115	6 5.7%			
15:00		83	74	-9 -10.6%	76	78	2 2.5%	197	194	-3 -1.5%	179	190	11 6.0%	119	122	4 3.2%			
15:30		150	135	-15 -9.9%	140	128	-12 -8.6%	275	241	-34 -12.2%	230	241	11 5.0%	187	158	-29 -15.6%			
16:00		165	177	11 6.7%	157	176	19 12.3%	299	269	-30 -10.0%	265	305	39 14.9%	212	221	8 3.9%			
16:30		171	187	16 9.6%	168	193	24 14.5%	307	261	-46 -14.9%	288	339	52 18.0%	225	256	31 14.0%			
17:00		171	191	20 11.9%	177	198	21 11.7%	307	265	-43 -13.9%	295	400	106 35.8%	246	298	51 20.9%			
17:30		217	231	14 6.3%	214	242	28 13.1%	333	298	-35 -10.5%	319	409	90 28.4%	268	315	47 17.3%			
18:00		219	248	29 13.4%	211	255	45 21.3%	350	328	-21 -6.1%	278	395	117 41.9%	219	303	84 38.4%			
18:30		201	237	36 18.0%	183	236	53 29.2%	313	320	7 2.1%	238	351	112 47.2%	175	263	88 50.4%			
19:00		102	157	55 53.6%	91	146	56 61.2%	190	233	43 22.5%	187	217	30 15.8%	131	135	4 3.2%			
19:30		46	72	25 54.1%	45	70	25 56.2%	127	142	15 12.0%	133	146	12 9.1%	78	72	-5 -6.9%			
	General Purpose Lanes																		
14:00	1584	1633	49 3.1%	1496	1455	-41 -2.7%	1420	1488	68 4.8%	1435	1515	80 5.6%	1339	1389	49 3.7%	1225	1372	147 12.0%	
14:30	1761	1797	36 2.0%	1660	1599	-61 -3.7%	1525	1585	60 4.0%	1515	1587	72 4.8%	1477	1476	-1 0.0%	1389	1466	77 5.5%	
15:00	1892	1910	18 1.0%	1731	1645	-86 -5.0%	1585	1648	64 4.0%	1578	1619	41 2.6%	1526	1521	-5 -0.3%	1487	1496	9 0.6%	
15:30	1770	1871	101 5.7%	1505	1577	72 4.8%	1527	1709	182 11.9%	1487	1626	139 9.3%	1446	1561	115 7.9%	1454	1536	82 5.6%	
16:00	1717	1891	174 10.2%	1246	1476	230 18.5%	1346	1568	223 16.5%	1242	1487	245 19.7%	1052	1281	229 21.8%	1094	1296	202 18.4%	
16:30	1813	1857	44 2.4%	1234	1435	201 16.3%	1339	1546	207 15.5%	1255	1443	188 15.0%	945	1123	178 18.8%	1005	1130	125 12.5%	
17:00	1848	1941	93 5.0%	1157	1489	332 28.7%	1306	1612	306 23.4%	1139	1563	424 37.3%	776	1071	295 38.1%	870	1055	185 21.2%	
17:30	1864	1907	43 2.3%	1111	1422	311 28.0%	1299	1569	270 20.7%	1152	1499	348 30.2%	752	1011	259 34.5%	830	992	162 19.6%	
18:00	1844	1866	22 1.2%	1143	1365	222 19.4%	1279	1498	220 17.2%	1154	1435	281 24.3%	820	1022	202 24.6%	863	1014	151 17.5%	
18:30	1889	1873	-16 -0.9%	1299	1377	77 6.0%	1373	1499	127 9.2%	1237	1420	183 14.8%	1008	1083	75 7.4%	1015	1101	86 8.5%	
19:00	1784	1820	35 2.0%	1499	1489	-9 -0.6%	1355	1507	151 11.2%	1312	1468	156 11.9%	1164	1277	113 9.7%	1179	1254	74 6.3%	
19:30	1444	1552	108 7.4%	1343	1386	43 3.2%	1228	1380	152 12.4%	1229	1358	129 10.5%	1119	1222	103 9.2%	1093	1205	112 10.2%	
	Total (GP + HOV)																		
14:00	1584	1633	49 3.1%	1539	1497	-41 -2.7%	1463	1533	70 4.8%	1619	1700	80 5.0%	1483	1550	67 4.5%	1315	1468	154 11.7%	
14:30	1761	1797	36 2.0%	1719	1658	-61 -3.6%	1582	1647	65 4.1%	1730	1798	68 3.9%	1644	1659	15 0.9%	1498	1581	83 5.5%	
15:00	1892	1910	18 1.0%	1814	1719	-95 -5.2%	1661	1726	66 3.9%	1776	1813	38 2.1%	1705	1711	6 0.3%	1606	1618	13 0.8%	
15:30	1770	1871	101 5.7%	1654	1712	57 3.5%	1667	1838	170 10.2%	1762	1867	105 6.0%	1676	1802	126 7.5%	1641	1693	53 3.2%	
16:00	1717	1891	174 10.2%	1411	1652	241 17.1%	1503	1745	242 16.1%	1541	1756	215 14.0%	1317	1586	269 20.4%	1307	1516	210 16.1%	
16:30	1813	1857	44 2.4%	1405	1623	218 15.5%	1507	1738	231 15.4%	1562	1704	142 9.1%	1233	1462	229 18.6%	1230	1386	157 12.8%	
17:00	1848	1941	93 5.0%	1328	1680	353 26.6%	1483	1810	326 22.0%	1446	1828	382 26.4%	1071	1472	401 37.5%	1116	1352	236 21.1%	
17:30	1864	1907	43 2.3%	1328	1653	325 24.5%	1513	1811	298 19.7%	1485	1797	312 21.0%	1070	1420	350 32.7%	1098	1307	209 19.0%	
18:00	1844	1866	22 1.2%	1362	1613	251 18.4%	1489	1754	264 17.8%	1504	1764	260 17.3%	1099	1417	318 29.0%	1082	1317	235 21.7%	
18:30	1889	1873	-16 -0.9%	1500	1614	113 7.6%	1555	1736	180 11.6%	1550	1739	189 12.2%	1247	1434	187 15.0%	1190	1365	174 14.6%	
19:00	1784	1820	35 2.0%	1601	1647	46 2.9%	1446	1653	207 14.3%	1502	1701	199 13.2%	1352	1494	143 10.6%	1310	1388	78 6.0%	
19:30	1444	1552	108 7.4%	1389	1457	68 4.9%	1273	1450	177 13.9%	1356	1500	145 10.7%	1252	1367	115 9.2%	1171	1277	107 9.1%	

Table A5. AM On-ramp Volumes, Westbound SR 520

	84th Ave NE				104th Ave NE - NB				104th Ave NE - SB				108th Ave NE			
	General Purpose															
Time	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change
5:00	16	15	-2	-10%	9	3	-6	-63%	21	20	-1	-5%	NA	7	NA	NA
5:30	36	37	1	2%	16	17	1	5%	55	38	-16	-30%	NA	16	NA	NA
6:00	66	58	-8	-13%	26	21	-5	-18%	110	89	-21	-19%	NA	32	NA	NA
6:30	119	101	-19	-16%	37	40	3	7%	204	184	-20	-10%	NA	66	NA	NA
7:00	198	158	-39	-20%	42	64	22	52%	270	258	-12	-4%	NA	92	NA	NA
7:30	294	205	-88	-30%	55	64	9	16%	325	246	-79	-24%	NA	120	NA	NA
8:00	314	217	-96	-31%	60	62	3	4%	307	241	-66	-21%	NA	108	NA	NA
8:30	252	185	-67	-27%	54	62	8	16%	256	213	-42	-16%	NA	98	NA	NA
9:00	186	148	-37	-20%	63	71	8	13%	194	172	-22	-11%	NA	89	NA	NA
9:30	161	142	-19	-12%	70	72	2	3%	152	142	-10	-6%	NA	81	NA	NA
10:00	140	128	-11	-8%	78	71	-7	-9%	139	117	-23	-16%	NA	68	NA	NA
10:30	138	137	0	0%	81	86	5	6%	137	118	-19	-14%	NA	82	NA	NA
	HOV															
Time	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change
5:00	0	0	0	0%	0	0	0	-75%	1	3	2	225%	NA	3	NA	NA
5:30	0	1	0	133%	3	0	-3	-90%	3	5	2	57%	NA	7	NA	NA
6:00	2	2	0	-7%	3	0	-3	-97%	6	7	0	7%	NA	13	NA	NA
6:30	1	3	2	160%	6	0	-6	-97%	6	10	4	69%	NA	20	NA	NA
7:00	2	15	13	700%	10	4	-7	-66%	13	20	7	54%	NA	31	NA	NA
7:30	4	48	45	1263%	9	4	-5	-52%	22	27	5	25%	NA	37	NA	NA
8:00	5	54	49	980%	10	2	-8	-78%	23	32	9	41%	NA	35	NA	NA
8:30	3	25	22	878%	9	3	-7	-72%	13	20	7	52%	NA	27	NA	NA
9:00	1	9	8	575%	12	2	-10	-85%	11	18	7	62%	NA	24	NA	NA
9:30	1	5	4	308%	15	1	-14	-95%	9	18	9	102%	NA	28	NA	NA
10:00	1	2	2	233%	15	2	-13	-90%	10	22	12	116%	NA	21	NA	NA
10:30	1	2	1	144%	14	1	-14	-94%	12	18	6	53%	NA	24	NA	NA
	Total (GP + HOV)															
Time	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change
5:00	16	15	-2	-10%	10	3	-6	-64%	22	23	1	4%	NA	9	NA	NA
5:30	36	37	1	3%	20	18	-2	-12%	58	44	-15	-25%	NA	23	NA	NA
6:00	68	59	-9	-13%	29	22	-8	-27%	116	96	-20	-18%	NA	45	NA	NA
6:30	121	104	-17	-14%	44	40	-4	-8%	210	194	-16	-7%	NA	86	NA	NA
7:00	200	173	-26	-13%	52	67	15	29%	283	278	-5	-2%	NA	123	NA	NA
7:30	297	254	-44	-15%	64	69	4	7%	347	274	-74	-21%	NA	157	NA	NA
8:00	319	271	-47	-15%	70	65	-5	-7%	330	273	-57	-17%	NA	143	NA	NA
8:30	255	210	-45	-18%	63	65	2	3%	269	233	-35	-13%	NA	125	NA	NA
9:00	187	157	-30	-16%	74	73	-1	-2%	205	189	-15	-7%	NA	113	NA	NA
9:30	163	148	-15	-9%	85	73	-12	-14%	161	160	0	0%	NA	108	NA	NA
10:00	141	131	-10	-7%	93	72	-21	-22%	149	138	-11	-8%	NA	90	NA	NA
10:30	139	140	1	1%	95	86	-9	-9%	149	136	-13	-9%	NA	106	NA	NA

Table A6. PM On-ramp Volumes, Westbound SR 520

	84th Ave NE				104th Ave NE - NB				104th Ave NE - SB				108th Ave NE			
	General Purpose															
Time	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change
14:00	160	161	2	1%	114	129	15	13%	150	135	-15	-10%	NA	82	NA	NA
14:30	185	161	-24	-13%	125	137	13	10%	153	127	-26	-17%	NA	87	NA	NA
15:00	211	198	-14	-6%	135	142	6	5%	165	142	-23	-14%	NA	106	NA	NA
15:30	278	208	-70	-25%	110	164	54	49%	192	169	-23	-12%	NA	117	NA	NA
16:00	422	207	-215	-51%	108	164	56	52%	214	186	-27	-13%	NA	115	NA	NA
16:30	527	220	-306	-58%	103	198	95	93%	246	207	-39	-16%	NA	108	NA	NA
17:00	619	221	-399	-64%	127	225	98	78%	305	247	-57	-19%	NA	127	NA	NA
17:30	640	212	-428	-67%	113	223	110	97%	278	251	-27	-10%	NA	113	NA	NA
18:00	592	204	-388	-65%	101	192	90	89%	253	210	-42	-17%	NA	95	NA	NA
18:30	474	191	-283	-60%	90	149	60	66%	205	175	-31	-15%	NA	79	NA	NA
19:00	248	146	-102	-41%	96	127	31	33%	161	125	-37	-23%	NA	67	NA	NA
19:30	136	90	-47	-34%	92	108	15	17%	115	99	-16	-14%	NA	52	NA	NA
	HOV															
Time	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change
14:00	1	4	3	267%	24	1	-22	-94%	14	29	14	98%	NA	25	NA	NA
14:30	3	9	6	225%	28	4	-24	-85%	17	24	7	42%	NA	26	NA	NA
15:00	2	19	17	1020%	23	2	-21	-90%	16	25	9	54%	NA	29	NA	NA
15:30	4	32	28	741%	20	5	-15	-77%	19	24	5	25%	NA	30	NA	NA
16:00	8	51	43	564%	21	13	-8	-40%	20	31	12	58%	NA	27	NA	NA
16:30	6	50	44	718%	21	19	-2	-10%	25	40	14	57%	NA	27	NA	NA
17:00	14	66	52	385%	26	23	-2	-9%	52	47	-4	-9%	NA	31	NA	NA
17:30	13	77	64	487%	26	21	-6	-22%	45	51	6	13%	NA	32	NA	NA
18:00	12	73	61	501%	24	23	-1	-5%	44	62	18	41%	NA	26	NA	NA
18:30	7	60	53	731%	21	13	-8	-38%	28	43	15	52%	NA	17	NA	NA
19:00	2	21	19	895%	20	6	-14	-69%	24	37	13	56%	NA	10	NA	NA
19:30	1	3	3	288%	20	1	-18	-93%	14	22	8	56%	NA	10	NA	NA
	Total (GP + HOV)															
Time	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change	2000	2001	Change	% Change
14:00	161	165	5	3%	138	130	-8	-6%	164	163	-1	-1%	NA	107	NA	NA
14:30	187	169	-18	-10%	153	142	-11	-7%	170	151	-19	-11%	NA	113	NA	NA
15:00	213	216	3	2%	158	144	-14	-9%	181	167	-14	-8%	NA	135	NA	NA
15:30	282	240	-42	-15%	130	168	39	30%	211	192	-18	-9%	NA	147	NA	NA
16:00	430	257	-172	-40%	129	176	48	37%	233	217	-16	-7%	NA	142	NA	NA
16:30	533	270	-262	-49%	123	216	93	75%	271	247	-24	-9%	NA	135	NA	NA
17:00	633	286	-346	-55%	152	248	96	63%	356	295	-62	-17%	NA	158	NA	NA
17:30	653	289	-364	-56%	140	244	104	75%	323	302	-21	-6%	NA	145	NA	NA
18:00	604	278	-326	-54%	126	215	89	71%	296	272	-24	-8%	NA	121	NA	NA
18:30	482	251	-231	-48%	111	162	52	47%	234	218	-16	-7%	NA	96	NA	NA
19:00	250	167	-83	-33%	116	133	18	15%	185	162	-23	-13%	NA	77	NA	NA
19:30	137	93	-44	-32%	112	109	-3	-3%	128	120	-8	-6%	NA	62	NA	NA

Table A7. 92nd Ave NE Off-ramp Volumes, Westbound SR 520

Time	2000	2001	Change	% Change
5:00	9	7	-2	-23.4%
5:30	19	24	4	21.8%
6:00	40	46	5	12.9%
6:30	79	90	11	14.3%
7:00	126	131	5	4.2%
7:30	130	129	-2	-1.3%
8:00	199	188	-11	-5.3%
8:30	118	122	4	3.4%
9:00	135	128	-7	-4.9%
9:30	127	125	-1	-1.0%
10:00	121	124	3	2.4%
10:30	127	124	-3	-2.4%
14:00	153	149	-4	-2.5%
14:30	173	161	-12	-6.8%
15:00	136	130	-6	-4.5%
15:30	148	124	-24	-16.3%
16:00	160	97	-63	-39.5%
16:30	136	72	-64	-47.2%
17:00	134	61	-72	-54.1%
17:30	127	59	-68	-53.8%
18:00	144	76	-68	-47.0%
18:30	148	85	-63	-42.6%
19:00	107	101	-6	-5.5%
19:30	87	89	2	1.9%

Table A8. Ramp Meter Turn On and Off Times, Westbound SR 520

	84th Ave NE	SB 104th to WB	NB 104th to WB	108th Ave NE	124th Ave NE
30-Jan-01	2:47 PM 7:03 PM	3:55 PM 6:53 PM	3:55 PM 6:53 PM	3:55 PM 6:53 PM	4:51 PM 6:02 PM
31-Jan-01	7:31 AM 8:32 AM 2:52 PM 6:43 PM	7:31 AM 8:31 AM 4:41 PM 6:42 PM	7:31 AM 8:32 AM 4:41 PM 6:42 PM	7:31 AM 8:32 AM 4:41 PM 6:42 PM	
1-Feb-01	6:51 AM 8:33 AM 3:36 PM 7:33 PM	7:17 AM 8:33 AM 4:30 PM 7:06 PM	7:17 AM 8:33 AM 4:30 PM 7:06 PM	7:18 AM 8:11 AM 4:30 PM 7:06 PM	
6-Feb-01	6:38 AM 8:58 AM 2:23 PM 7:24 PM				7:42 AM 8:17 AM 3:47 PM 6:46 PM
7-Feb-01	6:48 AM 9:48 AM 2:16 PM 7:06 PM	7:44 AM 9:29 AM 2:27 PM 7:06 PM	7:44 AM 9:29 AM 2:27 PM 7:06 PM	7:44 AM 9:29 AM 2:27 PM 7:06 PM	7:44 AM 8:20 AM 3:14 PM 7:06 PM
8-Feb-01	7:27 AM 9:17 AM 3:43 PM 7:21 PM	7:27 AM 9:17 AM 4:08 PM 7:17 PM	7:27 AM 9:17 AM 4:08 PM 7:18 PM	7:29 AM 9:17 AM 4:08 PM 7:18 PM	
13-Feb-01	7:34 AM 8:52 AM 3:09 PM 7:21 PM				
14-Feb-01	7:20 AM 8:54 AM 3:40 PM 7:31 PM	7:20 AM 8:54 AM 3:48 PM 7:31 PM	7:20 AM 8:54 AM 3:48 PM 7:30 PM	7:20 AM 8:54 AM 3:48 PM 7:30 PM	
15-Feb-01	6:41 AM 9:23 AM 3:39 PM 6:47 PM	7:13 AM 9:19 AM 4:28 PM 6:46 PM	7:13 AM 9:19 AM 4:28 PM 6:46 PM	7:13 AM 9:19 AM 4:28 PM 6:46 PM	7:25 AM 9:19 AM
Average AM on Average AM off Days used AM	7:06 AM 9:02 AM 8/9	7:25 AM 9:00 AM 6/9	7:25 AM 9:01 AM 6/9	7:26 AM 8:57 AM 6/9	7:37 AM 8:39 AM 3/9
Average PM on Average PM off Days used PM	3:07 PM 7:12 PM 9/9	3:53 PM 7:07 PM 9/9	3:54 PM 7:07 PM 9/9	3:54 PM 7:07 PM 9/9	4:13 PM 6:38 PM 7/9